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THE LITHOLOGICAL SECTION OF WALNUT CANYON, ARIZONA, WITH RELATION TO THE CLIFF-DWELLINGS OF THIS AND OTHER REGIONS OF NORTHWESTERN ARIZONA

By H. W. and F. H. SHIMER

Introduction

WALNUT Canyon, a short and narrow gorge, lies eight miles southeast of Flagstaff, Arizona (see fig. 28). It has been cut into a pine-clad, rolling plateau of upper Carboniferous (upper Aubrey) rocks to a depth of 380 feet. The lowest and uppermost beds are of sandstone ; the rest, comprising most of the section, are alternating limestones and dolomites containing a variable amount of quartz grains, and it is in the lower part of this portion, about 150 feet above the bottom of the gorge, in which all the celebrated cliff-dwellings occur.

Cliff-dwellings occur rather abundantly throughout New Mexico, Arizona, and southern Utah, but probably the most accessible of those which are well preserved are these of Walnut canyon. They are within the San Francisco mountain forest reserve and are thus under government control and protection. A United States forest officer lives at the canyon.

This canyon empties its waters into the Little Colorado river to the northeast; but during the dry season water remains only in scattered basins, yet is comparatively good for drinking.

The region is rather arid, most of the rainfall occurring as very heavy showers during the late summer. During a shower the erosive power of the stream then flowing through the canyon is very great, carrying off the talus at the base of the walls, widening and also deepening the canyon. This annual undercutting of the walls causes them to remain very steep. Because of the aridity of the climate the valley walls are worn back with extreme slowness.

In the Grand canyon of the Colorado, and in the gorges at

House Rock valley the downcutting is more rapid, and consequently the habitable caves are fewer.

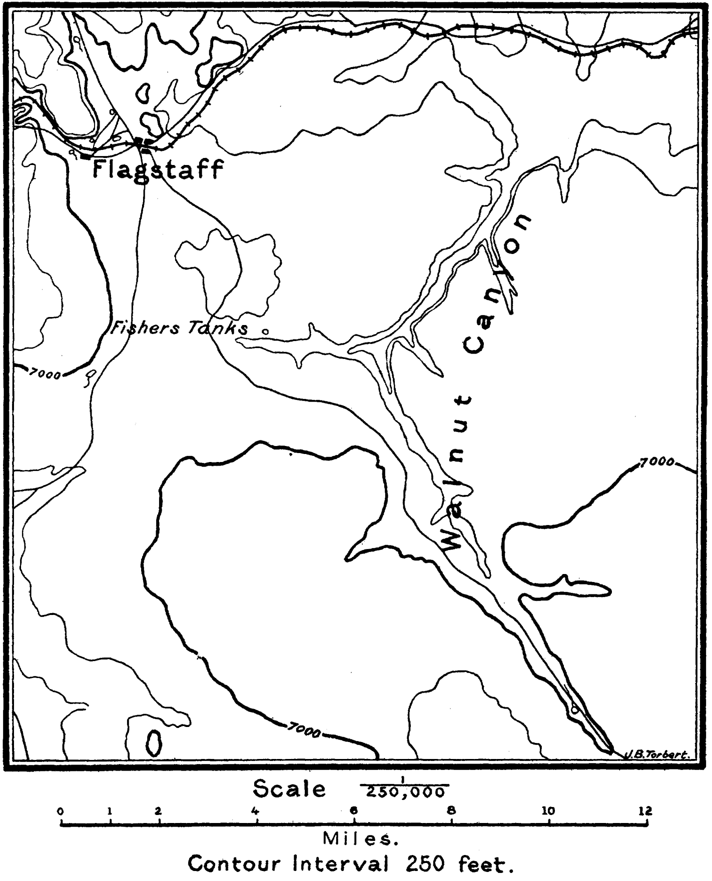

FIG. 28. — Topographic map of the Walnut canyon region; a portion of the U. S. G. S. San Francisco mountain sheet.

DETAILED LITHOLOGICAL SECTION OF WALNUT CANYON

The following is the detailed lithological section of Walnut canyon from the bottom to the top: it was taken at the foot of the upper trail, the one leading farthest east from the cabin of the forest reserve officer. The section there is quite accessible and is typical of the entire canyon where seen (see fig. 29).

1. Cross bedded sandstone........................75 feet

This forms the bottom and the narrowest portion of the canyon (fig. 30). The sandstone is light gray in color, and where exposed to the weather very long is friable. It is composed of pure quartz sand grains of a uniform size. The cementing material is largely calcareous.

2. Brownish-yellow sandstone........................10 feet.

The cement of these thin-bedded strata is mostly calcareous, to a slight extent siliceous and ferrous.

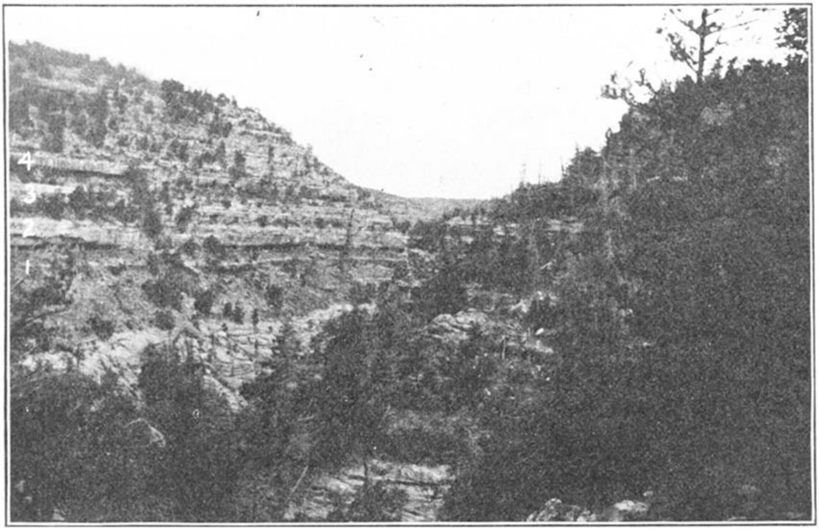

Fig. 29. — General view of Walnut canyon. The four prominent resistant zones are numbered.

3. Light gray sandstone........................12 feet.

This contains two thin brownish-yellow beds in the lowest three feet and a five foot one four feet from the top. The cement of the gray portion is dolomitic, effervescence occurring only in hot acid, and even then very slowly, leaving the scarcely diminished rock a mass of minute quartz grains. The uppermost one inch weathers back very readily; it has calcareous cement and effervesces very freely to a loose mass of rounded quartz grains. The entire zone is full of quartz concretions and geodes.

4. Yellowish limestone.................................15 feet.

Effervescence occurs very freely in cold acid leaving only a little residue of rounded to angular microscopic quartz grains. The limestone is very full of fragments of fossils. In the middle of this occur a 3- and a 6-inch band, about four feet apart, consisting of microscopic grained sandstone with much dolomitic cement; these weather back more readily than the remainder. The uppermost four feet is siliceous and very hard. The lowest foot and a half contain many quartz geodes.

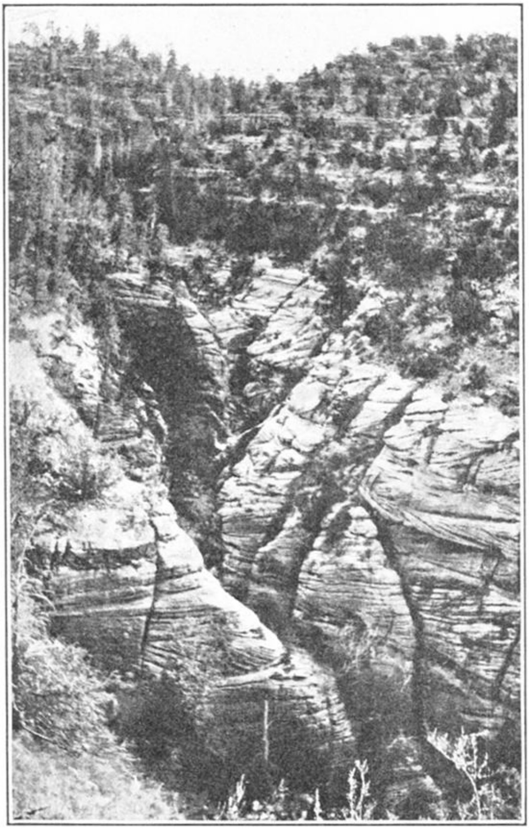

FIG. 30. — Bottom of canyon showing the cross-bedded sandstone.

5. Light gray limestone. ....12 feet.

In cold acid this effervesces very rapidly and falls apart. The little residue consists of minute, angular, and rounded quartz grains with a much smaller amount of argillaceous material. The rock is full of quartz geodes and concretions; the latter effervesce very slowly in cold acid, but, after boiling, the minute quartz grains are still held together by a siliceous cement. The concretions are merely portions of the rock mass hardened by the incorporation of magnesium and secondary silica as they contain quartz grains similar in amount and size to that in the rest of the bed.

6. Hard brownish-yellow dolomite . . . . 6 feet.

First resistant zone. This limestone is somewhat dolomitic and more resistant to weathering than zones 4 or 5 beneath or 7 and 8 above it. It thus projects as a conspicuous stratum. The dolomite contains more quartz grains than zone 5.

7. Soft, light gray limestone . . . . 11 feet.

Slope before first or lowest cave-zone. This limestone effervesces very freely to a small residue of rounded and angular microscopic quartz grains. Dolomitic concretions are quite abundant. This zone, intermediate in ability to resist the weathering agencies between zones 6 and 8, forms a slope between the two. Since there is a harder projecting 3-foot bed near the middle, it is upon the upper four or five feet of this slope over which runs the path before the dwellings of the first cave zone.

8. Grayish silicified dolomite and limestone . . . . 5 feet.

First cave zone. The lowest foot is highly silicified; when powdered it effervesces slightly in acid and leaves a mass of angular siliceous fragments among which are some quartz grains. This bed is very full of more highly silicified concretions and breaks into angular fragments at right angles to the stratification, or parallel to the weathering. The cause appears to be the compactness of the rock and the alternation of the day's warmth and night's cold. Alternate expansion and contraction of the compact siliceous dolomite thus caused is made non-uniform by the presence of the concretions. The rapid weathering back of this foot bed causes the upper four feet, a solid bed of slightly dolomitic limestone, to break off vertically into blocks. This is slightly reddish towards the middle and contains a considerable number of microscopic quartz grains. Since zone 9 is a solid stratum fifteen feet thick, it can withstand greater undermining before breaking off than is the case with this four foot bed; hence this latter becomes part of the cave. This cave zone is the most persistent and deeply weathered of the three, and here the vast majority of the dwellings are located.

9. Yellowish gray dolomite . . . . 15 feet.

Second resistant zone. This thick solid stratum projects as a very prominent ledge along the sides of the canyon forming the roof of the dwellings in the first or lowest cave zone (fig. 31). The rock is very full of quartz geodes superficially reddish in color. The weathering out of the geodes gives to the face of this cliff a pitted appearance.

10. Gray dolomite . . . . 8 feet.

Slope before second or middle cave zone. Portions of this thin-bedded zone might be called a dolomitic sandstone as they are composed almost entirely of small, rounded to angular quartz grains with a dolomitic cement. The three inches of sandstone at the base of the upper foot contain concretions whose cement is mainly silica. The entire eight feet is very full of quartz geodes superficially reddish in color. The thin-bedded character and the comparatively easy loosening of the quartz grains cause this to weather back more rapidly than zone 9, but as it retreats less rapidly than bed 11 it produces a slope along which runs the path before the dwellings of the second cave zone.

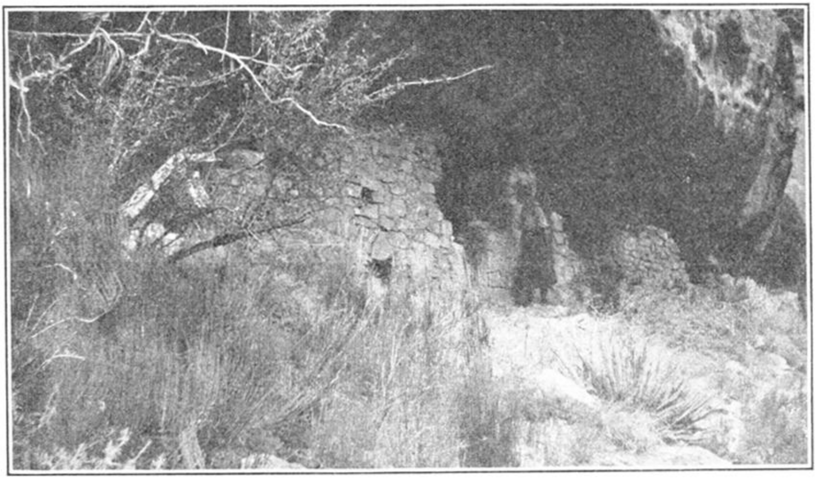

FIG. 31. — Near view of a cliff-dwelling showing its relation to the overhanging resistant zone (No. 2) and the pitted character of the latter.

11. Yellowish dolomite . . . . 5 feet.

Second cave zone. The basal foot is very full of concretions and weathers back more rapidly than the upper four feet, the two together forming this second persistent cave layer.

12. Yellowish dolomite . . . . 21 feet.

Third resistant zone. This consists of several distinct beds with the lower half more resistant than the upper. Most of the zone is full of reddish quartz geodes. Four feet from the base is a layer of broad, flat, lens-like concretions an inch or more thick, consisting of small rounded quartz grains united by a cement partly dolomitic but mostly siliceous. Seven feet below the top is a three inch layer of gray sandstone, with a considerable amount of dolomitic cement; this weathers more rapidly than the remainder of the zone, but, protected as it is by the quite resistant and more heavily bedded uppermost seven feet, it may be considered as a part of this third resistant zone.

13. Gray limestone to yellowish dolomite............12.5 feet.

Slope before upper or third cave zone. The lowest eight feet is a soft gray limestone weathering back very rapidly so that it causes the stratum beneath to project as a platform. The next foot is full of concretions and weathers white, retreating more rapidly than the upper three and one half feet which is a harder, yellowish dolomite; this latter forms the base of the few low caves located here; in one instance noted this and the concretionary foot were weathered back with zone 15, forming quite a high cave.

14. Light gray dolomite..............................4 feet.

Third cave zone. The base is a one foot concretion bed; the entire layer is full of quartz geodes.

15. Yellowish gray dolomite..........................14 feet.

Fourth resistant zone. Two feet from the top is a six inch layer of pink sandstone composed of minute, rounded, quartz grains, held together by a dolomitic cement; and seven feet from the base is a similar brownish layer.

16. Grayish dolomite................................20 feet.

This zone is composed of many distinct beds. The lowest foot, less dolomitic than the rest, weathers back more readily. The upper seventeen feet are quite light in color, the lower nine feet of which contain iron concretions ranging in diameter from one to seven and one half inches; these concretions consist of small rounded quartz grains held together with iron. Quartz grains are very abundant throughout this entire horizon.

17. Grayish limestone...............................38 feet.

This thickness of limestone is thin-bedded, and contains an abundance of minute fragments of fossils and a small number of microscopic quartz grains. Nine feet above the base occur many large siliceous concretions.

18. Dolomite and limestone .... 67 feet.

This thickness is an alternation of yellowish dolomite and gray to yellowish limestone; beginning at the base with dolomite the thicknesses are 3, 9, 8, 5, 11, 31 feet. Each of these weathers into thinner beds because of the varying amount of quartz grains and the apparently consequent greater or less degree of dolomitization. As a rule the limestones are full of minute fossils or fragments of fossils while the dolomites are barren; also the limestones contain very few quartz grains, while the dolomites enclose a considerable but varying number up to about 50 per cent. or more of the rock mass.

This zone 18 takes us to the top of the steeper portion of the canyon walls.

19. Gray to brown sandstone .... 20 feet.

Sloping up from the top of the canyon walls proper to the wagon trail on the surface of the plateau occurs this 20 feet of thin bedded sandstones. This was not noted in a continuous exposure but occurs as a succesion of ledges with the intermediate spaces of two or three inches covered with soil; this soil is probably underlain by more highly calcareous bands. This sandstone is solidified by a cement, partly ferrous, but mostly calcareous. The larger sand grains become more numerous in the topmost beds, the grains here averaging .2 mm. in diameter; these uppermost beds show cross bedding.

THE CLIFF-DWELLINGS AT WALNUT CANYON

It is in the cave-like groove formed by the erosion of the softer rock between two of these resistant beds that the cliff dwellings occur, the vast majority being about 150 feet from the bottom of the gorge. This long cave layer extending along the steep side of the canyon is divided into separate dwellings, usually with no connecting doors, by transverse walls built out from the back to the front of the cave.

One house of average size measured 15 feet in length, 10 feet in width or depth, and from 7 feet in height at the front to 4 feet at back. The floor was made approximately level by filling in the down-sloping front part with mortar. The front of the house is an artificial wall two feet thick built of native rocks of varying sizes joined by a yellowish-brown mortar of rather coarse sand such as is found in the bottom of the canyon. The stones are laid with a somewhat rough, perhaps accidental, approximation at breaking joints and the wall is even and straight along both the inside and the outside surface. This front wall reaches from the floor to the overhanging ledge and is pierced at center by a door nine inches wide at base, which though now broken away above, was probably originally less than five feet high. Against the roofing-ledge directly over the door is a round hole of four inches diameter, apparently a smoke outlet. The transverse walls forming the ends of the house are similar in thickness and material to the front wall which they join at a right angle.

Only rarely was there noticed an opening leading from one house directly into the adjoining. In one case such a connection was effected by a hole three feet high by two feet wide, its top being a flat piece of wood with ends embedded in the wall extending beyond it on each side.

That the fire was built in one of the back corners of the house was evidenced by the soot on the adjoining walls and roof and the presence of charred corn cobs, bones, and bits of wood.

Fragments of pottery indicating vessels of many sizes and shapes from jars to platters are extremely abundant both in and about the houses, but especially on the slopes in front. These ancient tenement dwellers apparently found the narrow streets before their houses as great a convenience into which to throw waste as did the ancient Romans described by Juvenal ; in either case the danger from falling pottery was probably at times very real.

The pottery is made of a coarse sandy clay. The most common ware is of a gray color with roughly geometric designs upon the outside in black ; those of red and black are comparatively rare. Second in abundance is the type in which the coiled structure appears on the surface, the coils being pinched down with the fingers.

Occasionally flat stones with raised sides, probably for grinding corn, are found in the dwellings. Of three such stones noted, two were of red sandstone and one of lava. Arrow heads of black obsidian and many chips of the same material were seen on the slopes before the houses.

On the cross-bedded sandstone in the base of the canyon, on the sides of a pot hole, was seen some pictorial writing quite similar to that in the petrified forest at Adamana and at Willow Springs.

A hundred yards back from the cliff and near the end of the upper trail are the ruins of a house. These consist of blocks of stones in low lines of irregular height, usually no more than a foot, but preserving the outline of the outside and the dividing walls. No two stones in place one above the other were noticed. The house is 14 feet wide and 36 feet long, extending in a north-south direction. It is divided into two parts, each 14 by 18 feet. A pine tree 67 inches in circumference at base now stands just within the southwest corner of the house. There is not much pottery around the house, but about 50 feet northeast of it the ground is covered with many such fragments among which were noted a few arrow heads and chips of obsidian.

Another house of one room about 9 by 9 feet was found about a third of a mile southwest of the forester's cabin. It is not so well preserved as the preceding, but the outlines of the walls can be made out. According to the resident forester at the canyon there are many such houses scattered over these uplands.

CLIFF-DWELLINGS OF OTHER LOCALITIES IN NORTHWESTERN ARIZONA

This feature of horizontal alternating soft and hard strata is constant over wide areas in Arizona, New Mexico, and Utah. But in most places water was too distant, erosion too rapid, or the resistant beds too thin to give either a cave of sufficient depth or the water to make it habitable. No dwellings were noted along the two trails traversed in the Grand canyon of the Colorado river, though a few caves of sufficient depth and height for habitation were noted.

In a small canyon cut into the eastern side of the Kaibab plateau, near House Rock ranch and opening upon the southern end of House Rock valley, several well preserved dwellings were found, as follows:

1. 30 feet above the bottom of the canyon. Semicircular with

floor flat, but roof and sides arching like a quadrant of a sphere. Diameter 8 feet, height from 0 to 1 foot in back, sloping up to 7 feet at the center of the semicircular entrance. On one side the encircling rock forms the bounding wall out to the edge of the slope, and on the opposite side a wall 5 feet long lay in ruins a foot high.

2. Nearly opposite 1 and worn out of the upper part of the same stratum. Apparently of same dimensions and shape, but with a wall built parallel to the front instead of at right angles as in 1. The wall now extends only half way across the front and judging by the straightness of its free edge never extended farther.

3. The largest cave of the three and that first seen on the left upon entering the canyon. The whole dwelling seems originally to have included nearly all the space under the huge cliff that extends about 30 feet in length and about 15 feet out over the eroded bed below. At the lower end of this 30-foot cave are the ruins of a wall extending from front to back. At the other end the cliff rock itself arches around in such a manner as to form the side wall; from this extends lengthwise a well preserved artificial wall extending to the roof; it is about 3 feet long by 3 feet high. Its free edge is comparatively straight and there are no ruins of a former extension; yet its present shape would offer but little protection.

Pottery fragments, bones, and burned stones were found.

It thus appears that the dwellings here could have been used only temporarily as none would have given sufficient protection for a permanent dwelling.

On the sides of Jacob's canyon upon the western side of the Kaibab plateau, and near its exit upon Kanab plateau, the upper Aubrey is very similar in bedding and lithology to that of Walnut canyon; the caves are, however, less pronounced and more like those of the Grand canyon. No dwellings were noted.

There are a few cliff dwellings in the upper Aubrey of the gorge cut into the western edge of the Uinkaret plateau at the Hurricane fault. This is just south of the village of Hurricane Bench, Utah.

CONCLUSIONS AND SUMMARY

In this semi-arid region the wind and also the great variations in temperature between night and day enter as factors in erosion, the latter causing vertical shaling of such a very compact siliceous bed as the lowest foot of zone 8, the former carrying off the loosened, dry sand grains and thus presenting fresh surfaces to weathering agencies.

The rocks at the base of the Walnut canyon section are thick, cross-bedded, pure sandstones. These change suddenly into evenly bedded strata with much calcareous cement, though still sandstone, probably representing the transgression of the sea upon an area of sand dunes. The lime content increases through zone 3 and in zone 4 becomes a limestone, though a solution of this still leaves a small residue of microscopic quartz grains.

From here through 238 feet to the uppermost beds (zone 19) there is an alternation of limestones and dolomites many times repeated, but all enclosing a varying amount of rounded to angular, usually microscopic, quartz grains ; it is notable that there is an almost complete absence of argillaceous material. Alternating with these strata, and occurring at intervals throughout the entire thickness of limestones are several thin bands of sandstones with a calcareous or dolomitic cement. The limestones usually consist almost entirely of small marine fossil fragments, and leave after solution in acid a very small residue of quartz grains ; the dolomites, usually granular, and with few or no fossils, contain a varying amount of quartz grains, probably averaging 30 per cent. to 50 per cent. of many of the beds. It was thus seen that it was the more porous strata which became dolomitic, the purer, less porous limestones remaining free from dolomitization ; but the pure sandstones vary in having either a calcareous or a dolomitic cement.

The uppermost beds of the section (zone 19,) are again a series of unfossiliferous sandstones like the base of the section, though less heavily bedded, and showing much less cross-bedding.

The 238 feet of calcareous beds lying between the cross-bedded sandstones at the bottom and top of the canyon walls are more heavily bedded in their lower portion, becoming quite thin-bedded towards the top. These rapidly alternating dolomites, limestones, and calcareous sandstones are quite variable in their resistance to weathering; the more resistant remain as ledges projecting out over the relatively softer undermining bed below until the weight becomes too great for the bed to support when they break off and roll down into the gorge. Since the thinner resistant beds would break off through less undermining than the thicker it is naturally in the lower portion of these calcareous beds where the strata are more heavily bedded that the caves occur. There are here four quite thick resistant beds; the lowest one occurs a short distance above the cross-bedded sandstone and has no caves of habitable size beneath it, but it forms the basement upon which is developed the lowest cave zone, the most persistent of the three prominent zones, and the one containing the vast majority of the hundreds of cliff dwellings located in this portion of the canyon. The second resistant bed, the one capping and forming the roof of these caves is the most conspicuous stratum above the cross-bedded sandstone. The other two resistant beds though prominent features in the canyon walls are much less so than the second, and from here to the top of the gorge no single bed or union of beds is of sufficient thickness to protect caves deep enough for dwellings.

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